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Project Based Learning Embedded with Entrepreneurship in Physics Learning to Improve Physics Application Ability

Ananda Aprilia[1*], Sukardiyono[2], Jumadi[2], Suparwoto[2], Rahayu Dwisiwi Sri Retnowati[2], Wipsar Sunu Brams Dwandaru[2]

[1] Magister of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[2] Physics Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

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Corresponding Author:
Ananda Aprilia
anandaaprilia.2022@student.uny.ac.id

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Abstract: This study aimed to determine the effectiveness and effect size of project-based learning (PjBL) model embedded with entrepreneurship in online physics learning to improve the physics application ability of senior high school students; and to describe students' responses to the entrepreneurship embedded PjBL model. This was a quasi-experimental study. The experimental design used was the clustered pretest-posttest controlled group design, which involved two groups and the sampling was carried out in clusters. This research was conducted at SMA Negeri 1 Mlati Yogyakarta on the subject of Elasticity and Hooke's Law. Data collection techniques in this study used tests and questionnaires. Data analysis utilized descriptive and inferential analysis. The results of the study showed that the application of the entrepreneurship embedded PjBL model was effective for improving students' physics application ability in the moderate category. The effect size of the entrepreneurship embedded PjBL model towards the physics application ability was in the moderate category. Finally, the student responses toward the entrepreneurship embedded PjBL model were in the very good category.

Keywords: Entrepreneurship; Physics application ability; PjBL

Introduction

Producing highly competitive human resources (HR) is a demand for developing countries like Indonesia. However, parents' concerns about their children after completing senior high school education have increased. This is happening in line with the increasing number of unemployed in the world including Indonesia with a limited number of job opportunities (Tugino & Hasanah, 2021; Haider et al., 2023). This is corroborated by data from the Central Statistics Agency (BPS) based on 2020 population census data, Indonesia's population in 2020 is 270.20 million (BPS, 2021) with an open unemployment rate in August 2020 of 7.07% or around 19 million people (BPS, 2020).

Various efforts have been made by parents, the community, and the government to prepare HR in facing the challenges of the globalization era in the 21st century. The challenge facing Indonesia is the increasing number of productive age population, which will peak in 2020-2035 when it reaches 70%. This means that not all children aged 19 - 23 years (high school and vocational high school graduates) can go on to university. As many as 70.1% of graduates are unable to continue on to university, while some of them do not yet have the skills to be involved in society because they do not have good attitudes, knowledge, and skills. One of these is entrepreneurship skills (Tugino & Hasanah, 2021).

The 2013 Curriculum is the implementation of 21st century skills consisting of critical thinking, creativity, collaboration, and communication (4C) (Ditjen PSMA, 2019). Many senior high school subjects are only academically and theoretically oriented and do not contribute to improving the economy through

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entrepreneurial activities. The structure of the 2013 Curriculum includes Craft and Entrepreneurship subjects, which provide students with a basic understanding of entrepreneurship skills. Through entrepreneurship learning, students can learn the theory and values of entrepreneurship that can be applied in real life through practice, both integrated in and outside the subjects or extracurricular activities. However, many young people are not interested in entrepreneurship. On the other hand, Indonesia will become a strong country if its citizens can take advantage of opportunities by doing entrepreneurship (Widiyarini, 2018; Luederitz et al., 2023). Therefore, efforts are needed to increase students' entrepreneurship skills. One solution is to implement an entrepreneurship program in high school by conducting entrepreneurship coaching, which is supported by all subjects so that it encourages students to be creative and independent.

Initial observations at a school show that students do not have entrepreneurship abilities. This can be seen from the low knowledge of students about entrepreneurship. In addition, the teacher also seems not to provide a supportive environment and atmosphere for the development of entrepreneurship programs in the classroom. Teachers are more focused on completing a particular material rather than providing knowledge about the importance of entrepreneurship for the future of students.

Physics is an important subject in senior high school as physics is developed through scientific progress and has great potential in supporting entrepreneurship programs. Physics is closely related to technology and engineering, which has economic values so that physics have the potential to support entrepreneurship. The essence of learning physics is not simply to remember and understand concepts, but it is very important for students to discover concepts through experiments or practicum (Susilawati, 2020).

One parameter for the success of the entrepreneurship program in physics subjects is the physics application ability. Students who have the ability to apply various physics materials certainly have the opportunity to apply physics they have learned in the business world, e.g.: selling physics-based products. Thus, this ability is essential to be mastered in supporting the entrepreneurship program. Initial observations show that students tended to think that physics lessons are difficult and only oriented toward mathematical concepts and formulas or equations. This is in accordance with Nordin et al. (2011) that science subjects are often considered very difficult, complicated, and not easily understood by students. In addition, learning physics in the classroom often only emphasizes the ability to remember and understand, so that physics application ability is often neglected (Nurani, 2018). The attitudes of students that tend to be negative certainly causes a low ability to apply physics (Santyasa et al., 2020).

An appropriate learning model to be applied in accordance to the Ministry of Education and Culture is the project-based learning (PjBL). By implementing the PjBL model, it is hoped that students become more active in solving problems and improve their skills in conducting projects, especially to implement physics concepts or theories (Aprida & Mayarni, 2023; Rusmansyah et al., 2023). This is because PjBL has an influence on student learning, particularly in science (Chistyakov et al., 2023). Moreover, the PjBL model is embedded with entrepreneurship activities to become entrepreneurship-embedded PjBL. The application of the entrepreneurship-embedded PjBL can certainly support the entrepreneurship program to prepare students to face the 21st century era.

The physics materials used are Elasticity and Hooke's law. These materials are considered appropriate in the implementation of the entrepreneurship-embedded PjBL model. The Elasticity material has been used to investigate the influence of PhET simulation-assisted PjBL on students’ ability to master physics concepts and creative thinking skills (Hadi et al., 2023; Doyan et al., 2023). Elasticity and the Hooke’s law are also implemented in the study of learning tools quality of problem-based learning (PbL) model (Buhungo et al., 2023). The influence of learning cycle 5e teaching model assisted by PhET media towards students’ learning outcomes has been investigated using the subject of Elasticity and Hooke’s law (Syaripudin et al., 2023). In fact, interactive learning media based on H5P has been developed for Elasticity material in mobilizing the school’s curriculum (Chasani et al., 2023). In this study, the project is producing a well-designed catapult following the Elasticity and the Hooke’s law material. The catapult produced is then decorated in order that it can be sold as a realization of the entrepreneurial aspect.

Method

This was an experimental study. The experimental design used was the pretest-posttest control group design of two classes seen in Table 1 (Sugiyono, 2010). In this case, the two classes were the experimental and control classes. The experimental and control classes received treatments of PjBL embedded with entrepreneurship and conventional learning models, respectively.

Table 1. The Experimental Design

Class	Pretest	Treatment	Posttest
Experimental	PE	Entrepreneurship embedded PjBL	PE′
Control	PC	Conventional	PC′

Note:
PE : pretest experimental
OC : pretest control
PE′ : posttest experimental
PC′ : posttest control

This research was conducted in the odd semester of the 2021/2022 school year at SMA Negeri 1 Mlati in Cebongan, Tlogoadi, Mlati, Sleman, Yogyakarta Special Region. The subjects in this study were students of XI MIPA classes at SMA Negeri 1 Mlati, namely XI MIPA 1 and XI MIPA 2 with a total of 72 students. The random cluster sampling was used to determine which XI MIPA classes were the experimental and control classes.

The data collection techniques used were tests and questionnaires. The tests were conducted to determine the effectiveness of the PjBL learning model embedded with entrepreneurship towards the ability of students' physics application. This test was carried out by giving the pretest and posttest. The questionnaire consisted of student response sheets. The aforementioned sheets were used to determine students' responses to the learning model.

The research instruments consisted of learning and data collection instruments. The learning instruments were syllabus, lesson plans, and student worksheets. Meanwhile, the data collection instruments were test questions and student response sheets**.** All instruments were developed by the researchers.

Table 2. Conversion of Scores into a Scale of Four

Score range	Category
$X > (\bar{X}_i + 1.5SB_i)$	Very good
$(\bar{X}_i + 1.5SB_i) > X > \bar{X}_i$	Good
$\bar{X}_i > X \geq (\bar{X}_i - 1.5SB_i)$	Bad
$(\bar{X}_i - 1.5SB_i) > X$	Very bad

The data analysis technique used was descriptive analysis through normalized gain with Hake criteria and minimum completeness criteria. The effectiveness of the learning model was determined via the effect size test. The analysis of student responses to the questionnaire used the ideal standards. The analysis steps at this stage were given as follows (Lukman & Ishartiwi, 2014): i) converting the qualitative data into quantitative data, i.e.: converting strongly agree, agree, disagree, and strongly disagree to 4, 3, 2, and 1, respectively; and ii) calculating the average score of each component of the statement for each student with categories consisting of four scales seen in Table 2. Here, four category ranges were obtained, namely: very good ($X \geq 3.25$), good ($3.25 > X > 2.50$), bad ($2.50 > X \geq 1.75$), and very bad ($1.75 > X$).

The pretest and posttest results were analyzed using the normalized gain formula to determine the improvement in students' physics application ability. According to Hake (1998) normalized gain can be determined by the equation 1, where $\bar{X}_{\text{posttest}}$ is the average value of the posttest, $\bar{X}_{\text{pretest}}$ is the average value of the pretest, and $\bar{X}$ is the maximum value of the test. $\langle g \rangle$ was categorized into five criteria, namely: there is a decrease ($-1.00 < \langle g \rangle < 1.00$), no increase ($\langle g \rangle = 0.00$), low ($0.00 < \langle g \rangle < 0.30$), moderate ($0.30 < \langle g \rangle < 0.70$), and high ($0.70 < \langle g \rangle < 1.00$).

$$\langle g \rangle = \frac{\bar{X}_{\text{posttest}} - \bar{X}_{\text{pretest}}}{\bar{X} - \bar{X}_{\text{pretest}}} \quad (1)$$

The learning completeness was determined based on the minimum completeness criteria set by the school, namely 75 for physics subject. The percentage of completeness was determined using the equation 2 (Indrawati, 2013). where p is the completeness percentage, L is the number of students who pass the minimum completeness criteria, and n is the number of students who did the tests. The criteria for learning completeness were based on the minimum completeness criteria consisted of five categories, namely: very effective ($p > 80\%$), effective ($60\% < p \leq 80\%$), quite effective ($40\% < p \leq 60\%$), less effective ($20\% < p \leq 40\%$), and not effective ($p \leq 20\%$).

$$p = \frac{L}{n} \times 100\% \quad (2)$$

The Shapiro-Wilk was used to conduct the normality test because the amount of data was less than 50. The data tested were the results of students' physics application ability. The equation utilized was (Sugiyono, 2010) on Equation 3. where D_n is the maximum deviation, $F_n(x)$ is the cumulative distribution function, and $F(x)$ is the theoretical cumulative distribution function.

$$D_n = \max|F_n(x) - F(x)| \quad (3)$$

Decision making in the normality test using the Shapiro-Wilk test was carried out through the following significance: i) if the significance value (Sig.) > 0.05 then the data were normally distributed and ii) if the significance value (Sig.) < 0.05 then the data were not normally distributed.

The homogeneity test was carried out to find out whether the variance of the data came from the same population. The data that underwent the homogeneity test were the results of the students' physics application ability. The homogeneity test was carried out based on the Levene's test using the equation 4 (Usmadi, 2020), where n is the number of observations, k is the number of groups, Z_{ij} is $|Y_{ij} - Y_i|$, Y_i is the average of group i, $\overline{Z}_i$ is the average of group Z_i, and $\overline{Z_{ij}}$ is the overall average of group Z_{ij}. The results of the homogeneity test can be given as follows (Usmadi, 2020): i) if the value of Sig. > 0.05 then the data were homogeneous and ii) if the Sig. < 0.05 then the data were not homogeneous.

$$W = \frac{(n-k)\sum_{i=1}^{k} n_i(\overline{Z}_i - Z)^2}{(k-1)\sum_{i=1}^{k}\sum_{j=1}^{n_j}(\overline{Z_{ij}} - \overline{Z}_i)^2} \quad (4)$$

After the normality and homogeneity tests were conducted, the difference test can be performed. The Mann-Whitney test can be conducted when the variables were independent and the data were non-parametric. Mann-Whitney test was an alternative of the t-test for independent populations when the normality assumption was not satisfied (Suyanto & Gio, 2017).

The effect size was a measure of the magnitude of the correlation or difference, or the effect of one variable on another. The Cohen's formula was used to determine the effect size is shows on Equation 5 (Retnawati et al., 2018), where d is Cohen's effect size, $\overline{X_1}$ is the experimental class mean, $\overline{X_2}$ is the control class mean, and S_{within} is the combined standard deviation. S_{within} was obtained from the equation 6.

$$d = \frac{\overline{X_1} - \overline{X_2}}{S_{within}} \quad (5)$$

$$S_{within} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}} \quad (6)$$

where n_1 is the number of students in the experimental class, n_2 is the number of students in the control class, S_1^2 is the standard deviation of the experimental class, and S_2^2 is the standard deviation of the control class. The effect size calculation results were interpreted using the classification according to Cohen (1997), namely: large (0.80 ≤ d ≤ 2.00), moderate (0.50 ≤ d ≤ 0.80), and small (0.20 ≤ d ≤ 0.50).

Results and Discussion

Student response questionnaires are used to find out student responses after they were treated with the entrepreneurship embedded PjBL model through student worksheets. The questionnaires are given to students in the experimental class. Questionnaire data analysis uses a Likert scale of 1 to 4. The results of the analysis of student responses using the ideal standards can be observed in Table 3. The student responses in Table 3 are in the very good category for the aspects of language; appearance; and quality, content, and purpose. Meanwhile, the presentation feasibility, instructional, and technical aspects are in the good category. Moreover, the average score of the students' responses was in the very good category.

Table 3. Students' Responses Analysis

Aspect	Average question (X)	Category
Language	3.30	Very good
Appearance	3.34	Very good
Presentation feasibility	3.13	Good
Quality, content, and purpose	3.26	Very good
Instructional	3.22	Good
Technical	3.23	Good
Average Score	3.25	Very good

The analysis is carried out on the values of the pretest, posttest, <g>, and minimum completeness criteria for the variable of students' physics application ability from the experimental and control classes. The results of the <g> analysis can be observed in Table 4. Based on Table 4, it can be said that students' physics application ability in the experimental class is higher than the control class. This is because the two classes are treated with different learning models. In the experimental class, physics learning is carried out using the entrepreneurship embedded PjBL model, while in the control class, physics learning is carried out using the conventional model.

Table 4. Results of 〈g〉 Analysis

Class	Physics application abilities	N-Gain	Category
Experiment	Pretest	0.61	Moderate
	Posttest		
Control	Pretest	0.45	Moderate
	Posttest		

Table 5. Results of the Minimum Completeness Analysis

Class	Physics application abilities	p (%)	Category
Experiment	Pretest	10.00	Not effective
	Posttest	80.00	Effective
Control	Pretest	20.69	Less effective
	Posttest	51.72	Effective enough

An analysis of the minimum completeness criteria is also performed. The minimum completeness criterion for physics subject is set to 75. The results of the analysis of the minimum completeness criteria for students' physics application ability can be observed in Table 5. The table shows that the PjBL model is effective for increasing students' physics application ability compared to the conventional model.

Table 6. Results of the Normality Test

Class	Normality test	Sig.	Category
Experiment	Pretest	0.06	Normal
	Posttest	0.81	
Control	Pretest	0.56	
	Posttest	0.10	

Prerequisite test analysis in this study used the normality, homogeneity, and hypothesis tests. The normality test used is the Shapiro-Wilk with the requirement that the data is normally distributed if the Sig. > 0.05. The results of the normality test for students' physics application ability can be observed in Table 6. Based on the results of the normality test, Sig. is greater than 0.05 for the experimental and control classes, which means that the data obtained is normally distributed.

Table 7. Results of the Homogeneity Test

Levene statistics	Sig.	Category
3.563	0.016	Not homogeneous

Table 8. Mann-Whitney Test Result

Mann-Whitney U	296.000
Z	-2.119
Asymp. Sig (2-tailed)	0.034

The homogeneity test used is Levene's test with the requirement that the variance of the sample data is homogeneous. In this case, the data has homogeneous variance if the Sig. > 0.05. The results of the homogeneity test can be observed in Table 7. Based on the results of the homogeneity test, the value of Sig. is 0.016, which is less than 0.05. So that it can be interpreted that the data obtained is not homogeneous. The results of the prerequisite test analysis of the normality and homogeneity tests for the pretest-posttest data on the physics application ability are used as the basis for implementing the Mann-Whitney difference test, which may be observed in Table 8. The result of the Mann-Whitney test on the physics application ability produces Asymp. Sig. value of 0.034. This aforementioned value is less than 0.05. Moreover, this means that there is a difference in the entrepreneurship embedded PjBL and the conventional models in improving the physics application ability of students.

In order to show the impact or effect of the difference obtained from the Mann-Whitney test, the effect size analysis is conducted. In order to do just that, the Cohen formula is used. The results of the effect size analysis of students' physics application ability can be observed in Table 9. Based on Table 9, the result of the effect size analysis for the pretest has a low category, while the posttest has a moderate category. This means that the standardized difference between the average values of the experimental and control classes has an effect with a moderate impact or effect.

Table 9. Results of Effect Size Analysis

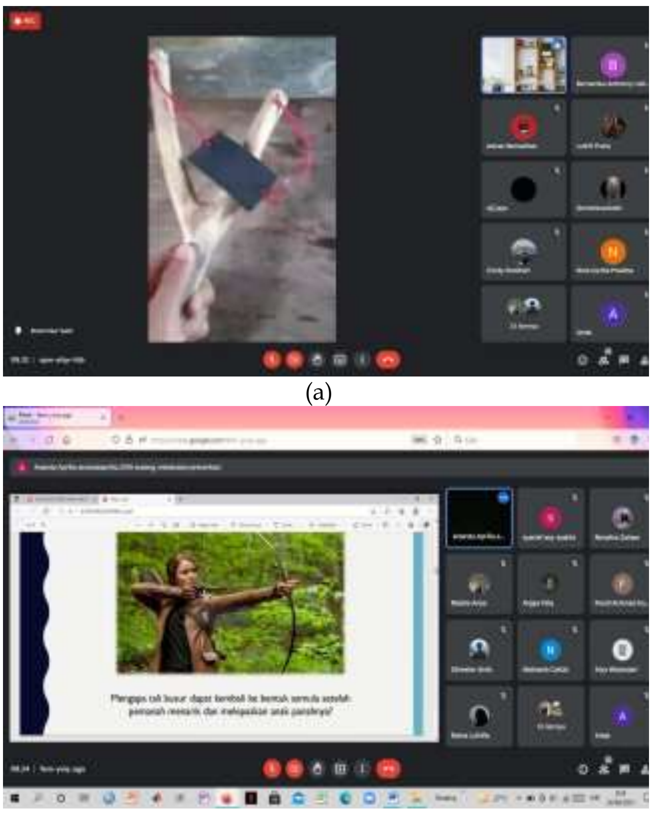
Physics application abilities	Cohen's effect size	Category
Pretest	-0.14	Low
Posttest	0.61	Moderate

From the analysis above, it can be stated that the PjBL model is effective in increasing the physics application ability of students. This is due to the emphasis on project activities in the entrepreneurship embedded PjBL learning. In the study, students are given project assignments in the form of making products based on Elasticity and Hooke's Law, namely a catapult. This catapult is then decorated so that it has the potential to be sold as a realization of the entrepreneurship aspect of the learning process. The existence of a project to produce catapult products is a manifestation of the ability to apply physics in the entrepreneurship embedded PjBL model. On the other hand, for the conventional model, videos and assignments for making reports are given to students instead.

The PjBL model developed in this study has been embedded with entrepreneurship. In this case, the entrepreneurship context is in the production of catapults, which are then decorated. Via decorations, it is hoped that the catapults can be sold at a certain price. This shows that the application of physics in the form of making catapults, can be used to trigger business ideas for students. The desire to make and decorate the catapults is an indication that students use knowledge of physics to be able to do entrepreneurship as a form of a personal responsibility (Gupta et al., 2023). Each catapult has different pattern and variety of decorations. Thus, the entrepreneurship aspect has been represented in the PjBL model. In addition, the entrepreneurship embedded PjBL model is effective in increasing the ability to apply physics, which then becomes a positive parameter for students' entrepreneurship potential and motivation. Furthermore, the knowledge of entrepreneurship that is obtained may be used by students in efforts to tackle the unemployment problem and obtain economic benefits (Olutuase et al., 2023). Improvement of the entrepreneurial aspect in this study can be done by formally selling the catapult products and embedding the entrepreneurial concepts to other physics learning material (Zeng et al., 2023).

Figure 1. A decorated catapult product

An example of the catapult product that has been produced by students can be seen in Figure 1. The existence of a project to produce this catapult product is an embodiment of the ability to apply physics in the PjBL model. This is because an important characteristic of PjBL is the well-designed product (Goldstein, 2016). Moreover, the detail of the catapult decoration in Figure 1 shows that students are engaged in making the well-designed product so that it can be sold as a part the entrepreneurship aspect (Makkonen et al., 2021).



(a)

Figure 2. Online learning in the (a) experimental and (b) control classes

The learning process of the experimental class (PjBL model) and the control class (conventional) can be observed in Figure 2. The learning process of both classes are conducted online. Figure 2(a) shows a student explaining the catapult product, while Figure 2(b) shows a conventional learning via power point presentation (PPT). In the experimental class, which was treated using the entrepreneurship embedded PjBL, students tend to ask questions regarding the project. In contrast, in the control class given conventional learning model, students tend to be passive (Hidayati et al., 2023; Rafiq et al., 2023). Moreover, in the PjBL learning model, students tend to work collaboratively compared to the more individual work in the conventional learning model (Krajcik et al., 2022).

The results in this study are supported by the research of Siwa et al. (2013), which showed that the PjBL model is able to optimize students' skills. In addition, the PjBL model has a better influence in stimulating and developing skills so as to improve students' skills and make learning activities more enjoyable and meaningful (Piliang, 2019; Wahdah et al., 2023). This is in line with this research that has been done showing the PjBL model can improve the physics application ability.

Conclusion

Based on the results and analysis of the research that has been carried out, it can be seen that in terms of physics application ability, standard gain values are obtained in the moderate category. Apart from that, learning physics using the entrepreneurship embedded PjBL model has an influence on improving physics application ability with moderate effect size criteria. Students' responses to the worksheet of the entrepreneurship embedded PjBL model have an average score for all aspects in the very good category. Thus, physics learning using the entrepreneurship embedded E-PjBL model is effective to improve physics application ability.

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Author Contributions

Conceptualization, Suk., Jum., Sup., and R.D.S.R.; methodology, W.S.B.D; software, A.A.; validation, Suk. and W.S.B.D.; formal analysis, A.A.; investigation, A.A.; resources, Jum.; data curation, A.A.; writing—original draft preparation, A.A..; writing—review and editing, A.A. and W.S.B.D; supervision, Suk.; project administration, R.D.S.R.; funding acquisition, Jum. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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